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ABSTRACT

This study is designed to develop teaching materials, including a student text and a teacher's manual, for a new descriptive statistics curriculum unit for the mathematics curriculum of the first 2 years in the Junior College of Commerce or the business high school in Taiwan. Other goals of the study included investigating the appropriateness and effectiveness of the curriculum as well as the difficulties in teaching and learning the unit. Results indicate that the students did not have serious difficulty in learning the descriptive statistics unit although many have difficulty with the meanings of class limits, sketching the relative frequency distribution graphs, and correctly computing the measures of central tendency for grouped data. The curriculum components are critiqued by experts in the field and a discussion of their reactions is included. Results imply that descriptive statistics is of higher interest to more students than some of the traditional mathematical topics. Data also suggest that the "thinking aloud" procedure should be examined more closely in future studies. (Author/DDR)

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A Descriptive Statistics Curriculum Unit for The Mathematics Curriculum in The Junior College of Commerce

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A Descriptive Statistics Curriculum Unit for The Mathematics Curriculum in The Junior College of Commerce

ABSTRACT

This study was designed to develop teaching materials, including a student's text and a teacher's manual, for a new descriptive statistics curriculum unit for the mathematics curriculum of the first two years in the junior college of commerce or the business high school in Taiwan and to investigate the appropriateness and effectiveness of the curriculum unit and the difficulties in teaching and learning the unit. The statistical contents were well designed and developed. Some procedures of exploratory data analysis, such as stem-and-leaf display and boxplot, were integrated in the curriculum materials.

The curriculum unit was designed in the fall of 1983. A pilot study was completed in the Winter Quarter of 1984 at the University of Georgia in the United States of America. The major study was carried out from April to October of 1984 at the National Taipei Junior College of Commerce in Taiwan. The teaching materials were tried out three times and revised after each tryout.

The experts' comments on the teaching materials were generally favorable. The major advice on revising the student's text and the teacher's manual was to include the topic of measures of deviation and to reduce the coverage of other statistical topics. The classroom students' reactions to the text and the instruction were generally favorable. They liked the cartoons, summaries, statistical anecdotes, discussions and questions provided in the text. The content on stem-and-leaf display was interesting for them.

The students also liked the inquiry method and the discovery lessons.

Experts' commen's and field trials are essential for developing a curriculum. During a tryout, tests, questionnaires, and interviews are effective instruments to investigate students' learning difficulties and their reactions to the text and the instruction.

Deliberating the experts' arguments and the results from the pretest, posttest, and examinations, I can say that a descriptive statistics unit appears appropriate for the mathematics curriculum in the junior college of commerce in Taiwan.

KEY WORDS: Descriptive Statistics Curriculum Unit, Grade 11, Mathematics Curriculum, Junior College of Commerce, Business High School, Commercial and Daily-life Problem Solving, Developing A Curriculum, Evaluations, Field Testing, Effectiveness of The Curriculum Materials, Exploratory Data Analysis, Stem-and-leaf Display, Boxplot.

INTRODUCTION

The junior college is a special educational unit in Taiwan that provides five-year courses to train professional specialists. Students who have completed grade 9 are allowed to take the entrance examination for the junior college. The junior college of commerce provides mathematics courses for the first two years. The content of the two-year mathematics courses is of the high school level. I had found that the textbooks for the courses were not well-prepared. Most of them lacked business applications and guidelines for teaching. Moreover, there was no statistical content in the mathematics curriculum. Therefore, the innovation of the curriculum materials for the first-two-year mathematics courses was necessary.

Purpose

I thought that it was timely to design a better mathematics curriculum and develop the teaching materials for the teachers and the students in the first two years of the junior college of commerce and the business high school. The purpose of this study was to produce a curriculum unit on descriptive statistics and to pioneer in integrating the techniques of exploratory data analysis into statistics textbooks in Taiwan. I hope that the incorporation of statistical content into the traditional mathematics curriculum can stimulate a new approach to the development of mathematics textbooks for business schools. I also hope that the focusing of the business school mathematics curriculum on commercial and daily-life problem solving will be widely adopted by textbook writers.

Research Questions

This study was intended to investigate the following questions:

1. How appropriate is this curriculum unit for Grade 11 students in junior

colleges of commerce in Taiwan?

2. What are the difficulties in teaching or learning this curriculum unit?
3. How effective is this curriculum unit in terms of students' performance?

Rationale

Statistical concepts and procedures are very useful in coping with problems of daily life and with scientific investigations. Statistical reports also appear frequently in magazines, journals, television programs, and radio broadcasts. The prevalence of statistical data makes some knowledge of statistics indispensable. Living in society, we need to learn statistics so that we can better understand and communicate statistical expressions and analyses. In particular, business and management science rely on statistics. Statistical concepts and procedures have become essential and useful for making commercial decisions. I think that it is better for students in the business school to learn statistics as soon as possible.

In the United States, the statistical content and applications have been recommended for students at the high school level since 1950. The National Advisory Committee on Mathematics Education [1] and the National Council of Teachers of Mathematics (NCTM) [2] have strongly recommended that descriptive statistics be included in the mathematics curriculum. As a result, most of the high school mathematics textbooks published in the 1980s contain some content of statistics. In many other countries, such as England, Sweden, Hungary, and west Australia, the high school mathematics curriculum also includes statistical unit. In Taiwan, only the textbook for the junior college of teacher training contain a little content of statistics. According to the new curriculum design for the college-preparatory high schools, there will be statistical content provided for Grade 11 students in the second semester. However, no statistical content has been included in the mathematics curriculum for the junior college of commerce.

Students in some departments cannot learn statistics through their study in the junior college of commerce. On the other hand, educators advocate a spiral curriculum. If we can teach descriptive statistics in Grade 10 or 11, students will be able to learn statistics better. They will also be able to understand statistics or deal with statistical problems better in daily life. Therefore, I strongly recommend a statistical unit be included in the mathematics curriculum for the junior college of commerce or the business high school.

I advocate that problem solving be the focus of the statistical unit. Throughout history, problem solving has been an essential activity in mathematical teaching and research. Lester [3] argued that problem solving must be at the heart of all mathematics, and Begle [4] claimed that "the real justification for teaching mathematics is that it is a useful subject and, in particular, that it helps in solving many kinds of problems" (p. 143). The National Council of Supervisors of Mathematics [5] also agreed that "learning to solve problems is the principal reason for studying mathematics" (p. 148). The NCTM [2] recommended that "the mathematics curriculum should be organized around problem solving" (p. 2); "appropriate curricular materials to teach problem solving should be developed for all grade levels" and the "mathematics programs of the 1980s should involve students in problem solving by presenting applications at all grade levels" (p. 4). Moreover, the NCTM recommended that problem solving be the focus of school mathematics in the 1980s.

I also advocate that the concepts and procedures of exploratory data analysis be integrated into the statistical unit. Tukey [6] said "Exploratory data analysis is detective work — numerical detective work — or counting detective work — or graphical detective work" (p. 1). Velleman and Hoaglin [7] said "[Tukey] has expounded a practical philosophy of data analysis which minimizes prior assumptions and this allows the data to guide the choice of appropriate models" (p. xv). The content of exploratory

data analysis provides the context of discovery. In particular, the graphical methods of exploratory data analysis can increase interest and usefulness in the statistics course. Many statisticians or educators, such as P. A. Tukey [8] and Bibby [9], suggested that the concepts or procedures of exploratory data analysis be integrated into a statistical unit for school students.

REVIEW OF THE LITERATURE

Statistics in The School Mathematics Curriculum

The recommendation that statistics be taught in schools can be traced to the 1923 report of the National Committee on Mathematical Requirements (Jones [10], p. 207), the Harvard report in 1945 (Jones, p. 242), and the report of the Commission on Post-War Plans of the National Council of Teachers of Mathematics in 1947 (Jones, p. 246). Teaching statistics in schools was strongly recommended by the Council of the Royal Statistical Society in 1947 and the Committee on Teaching of Statistics of the Institute of Mathematical Statistics in 1948. In 1959, the Commission on Mathematics recommended descriptive statistics as an optional topic for Grade 9 (Jones, p. 263) and introductory probability with statistics applications as an additional alternative unit for Grade 12 (p. 261). Additionally, the Cambridge Conference [11], the Joint Committee of the American Statistical Association and the NCTM, and the NCTM [2] also recommended that statistics be included in the school mathematics curricula.

During the first International Conference on Teaching Statistics (ICTS, 1982), several statisticians discussed the necessity and possibility of providing a statistics course for school students. Many statisticians were convinced that statistics should be taught at the school level. They also realized that there were still some obstacles in introducing statistics to schools. However, they agreed that some statistical content can be included in the mathematics course and school teachers can be trained through in-service education. In the conference, statisticians also discussed the inclusion of exploratory data analysis in the course. They thought that there seemed to be a place for EDA ideas at the high school level and that certain EDA materials was more suitable for younger children.

Some important mathematics curriculum development projects in

America or England, such as the Secondary School Mathematics Curriculum Improvement Study, the Joint Committee on the Curriculum in Statistics and Probability, the Mathematics Resoruce Project, the School Mathematics Project, and the Schools Council Project on Statistical Education, prepared statistical content for school students. Many mathematics textbooks published in the 1980s also contained statistical content. although statistics has been taught in the junior middle school and elementary school for a long time in Taiwan, no more content has been offered in the high school. However, in the spring semester of 1986, there will be statistical content included in the mathematics course for Grade 11 students. I think that it is timely to provide a statistical unit in the mathematics curriculum for the junior college of commerce and the business high school.

Features in the School Mathematics Textbooks

I have reviewed about 100 American high school mathematics textbooks published in this century. I found that 24 of them contained some content on descriptive statistics. Among these textbooks, 1 was published in 1935, 2 in the 1950s, 6 in the 1960s, 7 in the 1970s, and 8 in the 1980s. About 60 of the 100 textbooks were published between 1974 and 1984. There were several common features. Most books provided examples, application problems, a summary, review problems, test items, and exercises with a brief answer to each exercise question and detailed answers to selected exercises at the end of the books. Most books also used colored words and a bold-face type. Some books had historical notes and tasks on flow charts. Some books, especially in the 1980s, provided calculator applications, programming tasks, problem-solving tasks, and enrichment tasks. The teacher's manuals associated with the textbooks were well prepared. Generally they contained the objectives for each chapter, a lesson commentary including teaching suggestions for each chapter or section, the distribution of instructional time, the assignment guide, the supplementary materials in-

cluding problems for testing, and the answers to all problems in the text and the manual.

I have reviewed five sets of high school textbooks from the Republic of China published after 1965. There were 10 volumes in each set. I have also reviewed the mathematics textboks for the business high school, for the junior college of commerce or technology, and for the junior college of teacher training. In addition, I have reviewed the contemporary mathematics textbooks for the elementary school, the contemporary textbooks and the experimental texts for the junior middle school, and the experimental texts for the senior high school. I have found that most textbooks, except for two sets, for the high school or the junior colleges contained no statistical content. Those textbooks for the high school or the junior colleges have uniform formats. Generally a brief introduction is provided, followed by definitions, theorems together with proofs, and examples. At the end, some exercise problems are provided. A chapter may have more than one exercise. There are no answers to the exercises in the student's texts. The answers to the exercises are given in the teacher's manual. As to the teacher's manual, only some provide more detailed prescriptions and reference materials for instruction. Many manuals contain only answers to the exercises in the student's textbooks.

Among the mathematics textbooks published in the 1980s that I reviewed, 10 contained descriptive statistics. I have found that the sequences of statistical topics presented in the ten textbooks were quite varied. Even within each topic, the sequences of the statistical concepts and procedures might also be different. Eight of the 10 textbooks provided the statistical content in only one chapter. The statistical content was presented in two consecutive chapters in one set of the textbooks and scattered in eight nonconsecutive chapters in another textbooks. Generally, the statistical content was placed right after the chapter on probability. There were no concepts or procedures of exploratory data analysis included in the 10 sets of

the textbooks. The most common statistical topics included in the books were frequency distributions, statistical tables, statistical graphs, measures of central tendency, measures of deviation, probability distribution, correlation, and sampling.

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CURRICULUM PLANNING AND PILOT STUDY

In October 1983, I decided to develop a curriculum unit on descriptive statistics for Grade 11 students in the junior college of commerce and the business high school in Taiwan. The philosophy for developing the curriculum materials has been discussed in the preceding sections. The objective of this unit was to provide elementary statistical knowledge and procedures for students to use in dealing with problems in daily life or business. The procedures for developing the materials were similar to those used in most curriculum development projects. Asking for evaluations from experts and students was an essential procedure in the developing process. In this study, I am a curriculum designer, textbook writer, classroom teacher who tried out the materials, and curriculum investigator who investigated the students' reactions.

Under the guidance of the philosophy and the objective, I proposed an outline of the curriculum plan and carried out a pilot study. The work was not completed until late March of 1984.

Curriculum Planning

At this stage, I discussed the proposed unit with three mathematics educators and one statistician. For planning the curriculum, eight American mathematics textbooks and one Chinese high school mathematics textbook published in the 1980s that included statistical content and some of their commentaries were taken as reference books. Besides those books, other reference materials, including books and articles on statistics were also used [12].

In November 1983, I proposed the outline of the initial curriculum plan. After discussing with the experts, the outline was revised as follows:

Chapter 1. Introduction

1.1 The Importance of Statistics in Commerce

1.2 The Classification of Statistics

1.3 Data Level

1.4 Variables, Constants, and the Classification of Variables

Chapter 2. Collection, Arrangement, and Display of Data

2.1 Populations and Samples

2.2 Frequency Distribution and Cumulative Frequency Distribution

2.3 Relative Frequency Distribution and Cumulative Relative Frequency Distribution

2.4 Stem-and-Leaf Displays

2.5 Pie Charts

2.6 Bar Graphs

2.7 Histograms

2.8 Frequency Polygon

2.9 Cumulative Frequency Polygon

Chapter 3. Measures of Central Tendency

3.1 Brief Introduction

3.2 Mode

3.3 Median (including Quartile, Percentile, and boxplots)

3.4 Arithmetic Mean (including Weighted Arithmetic means and Trimmed Means)

Note. 1. In some lessons, the history of statistics will be introduced to motivate students' learning.

2. A summary of each chapter will be provided.

3. At the end of every chapter, the exercises will be classified into three difficulty levels.

4. Some discovery lessons may be provided in the text for students to have a chance to discover patterns of data

Pilot Study

A pilot study was carried out from December 1983 to March 1984 at the University of Georgia. I developed a section on the stem-and-leaf display. The teaching materials, including a student's text, a teacher's commentary, and an instructional plan, were ready in January 1984. They were sent to 12 volunteer faculty members in the Unviersity of Georgia to ask for evaluation. Based on the experts' advice and comments, the teaching materials were revised. Then the text, the teaching methods, and the instructional plan were tried out in a classroom. Getting feedback from the students, I revised the teaching materials again.

Developing the teaching materials. The teaching materials on the stem-and-leaf display were written in English. The reference books used for developing this section were McNcil's, Tukey's, and Velleman and Hoglin's [12]. MacDonald's paper [12] was also taken as reference. On January 20, 1984, the student's text, the teacher's commentary, and the instructional plan were ready.

The student's text contained 16 pages. There were five examples and four exercise problems. The first example was used to illustrate the procedure of the stem-and-leaf display. The teacher's commentary contained 12 pages. There were seven sections: Objectives, Notes, Some Important Concepts, Supplementary Materials, Answers to the Exercises, Additional Examples or Exercises That Can Be Used for Testing, and References. The instructional plan contained only four pages.

Experts' evaluations. There were 12 professors at the University of Georgia who agreed to help evaluate the teaching materials. However, only 10 of them returned their evaluations. Each of the 12 professors was given a letter, a questionnaire, and copies of the teaching materials.

By February 18, 1984, I got the responses from the 10 experts. Then I began to analyzed the data. The most important feedback from the ex-

perts concerned the presentation of the procedure of making a stem-and-leaf display. In constructing a frequency distribution, one should decide the length of the intervals in the distribution and the number of interval that one wants. I used the same approach to develop a procedure for making the stem-and-leaf display as McNeil did (1977). Some experts found it confusing and suggested that I use the "splitting adjacent position" approach as Tukey (1977), Velleman, and Hoaglin (1981) did. Another issue concerned the use of the symbols and letters, that is, *,T, F, S, and #, to distinguish the five rows with the same stem value. Considering varied opinions from the experts, I changed to use the letters z, t, f, s, and e. Experts suggested adding labels for the displays and providing more exericse problems.

Concerning the teacher's commentary, experts suggested giving more statistical activities for reference. Experts also suggested that the essential points in the instructional plan be included in the teacher's commentary.

Students' Evaluations. In March 1984, the teaching materials were revised the first time. Then I tried them out in the classroom. Seven undergraduate students in the University of Georgia volunteered to join the study. I sent a copy of the revised student's text to each student just two days before the classroom instruction. My lecture covered 12 pages of the text that included the content before Example 2. It took about one hour. After the class, the students took a 10-minute break. Then an open-book test was given that asked the students to do Exercises 1 and 2 in the text and answer some related questions. The test took about 25 minutes. When a student finished the test, he or she was asked to answer the questionnaire to write down his or her reactions to the text and my instruction.

From the test, I found that the major mistake in the students' answers was that the leaf digits were not well arranged in columns. To emphasize this point, I added a statement at Step 4 of the procedure of making a stem-and-leaf display and put a note in the teacher's manual to ask the teachers to pay attention to this point. From interviews, I found

that students were not confused by the symbols z, t, f, s, and e. Therefore, I decided to preserve the notations. The students' reactions to the text and my instruction were generally favorable.

DEVELOPING THE CURRICULUM UNIT

The section on the stem-and-leaf display was developed in the pilot study. The other sections of the curriculum unit were written in April and May 1984, except for the last section, on the measures of deviation, which was developed in September 1984.

I went back to Taiwan on March 30, 1984, and began to collect some reference materials, including Chinese statistics books and statistical publications, for developing the curriculum unit. The curriculum materials, including a student's text and a teacher's manual, were written in Chinese.

The Student's Text

The first edition of the student's text was written by following the syllabus presented in the revised outline of the curriculum unit. There were three chapters in the text that contained 16, 78, and 33 pages respectively. Each chapter contained summaries, extra problems, and exercises. Some programming tasks were provided as extra problems or exercises. Some exercises about collecting statistical data were also given. At the end of some sections, statistical anecdotes, statistical talks, statistical questions, and statistical expressions in daily life were provided. Cartoons were prepared at some places.

The Teacher's Manual

The first edition of the teacher's manual contained 64 pages. Before chapter 1, there was a general introduction on the philosophy, rationale, and purpose of the curriculum unit, the instructional goals, the instructional methods, the uses of teaching aids, the use of the calculator, and the reference. The manual proposed seven instructional approaches for teaching the curriculum unit: (a) lecturing, (b) inquiry, (c) discovery, (d) discussion, (e)

sequential (that is, to use some typical examples to teach statistical concepts and procedures sequentially to connect the statistical topics in different sections), (f) statistical activity, and (g) computing. I recommended the set square, compasses, colored chalk, dice, poker cards, statistical wall charts, transparencies, and the proejctor as teaching aids. I also recommended the use of the calculator for computation.

For each chapter, I provided instructional goals, instructional methods and key points, supplementary materials and references, reference examples and exercises, allocation of instructional time, and solutions of problems or exercises.

For teaching each chapter, some reference books and articles were also provided. I also advised teachers to select teaching approaches.

DESCRIPTION OF TRYOUTS AND EXPERTS

Trying out The Curriculum Materials

From May to October in 1984, the teaching materials were tried out in the National Taiepi Junior College of Commerce (TJCC) three times. The first tryout was with Grade 11 students and took place from May 1 to June 16 — during the last part of the second semester. The second tryout was in August, which was the last month of the summer vacation. The students taking in part in the second tryout had just completed either Grade 10 or Grade 11. The third tryout was from September 3 to October 2, which was the beginning of the first semester. The students were in Grade 11.

Tryout 1. Three classes participated in Tryout 1. One class came from each of the three departments: Business Administration, Secretarial Training, and Electronic Data Processing. There were 51, 48, and 53 students in the three classes. Copies of the student's text were prepared and distributed to the students in three sections. Usually the students got the pages before the content of the pages was taught. I taught the students four periods a week. There were two tests in this tryout. I spent only 12, 13, and 14 periods for each class teaching the first two chapters of the planned curriculum on descriptive statistics. The last chapter on measures of central tendency was not taught. Some students were interviewed during the tryout. At the end of the tryout, there were 14, 17, and 11 volunteer students in the three classes who responded to the questionnaire that asked their opinion of the text and my instruction.

Tryout 2. There were 38 students from the TJCC and 5 students from other junior colleges of commerce. However, the number of the students decreased from the beginning to the end. There were three tests in this tryout. Only 24, 10, and 5 students took the three tests respectively. There

were 12 students who were interviewed and 5 students who responded to the questionnaire.

Tryout 3. The students were in one of the Grade 11 classes in the Department of International Trade in the TJCC. There were 50 students in the class. Two tests were given in this tryout and 49 students took each of the tests and responded to the questionnaire.

Experts

On June 8, the student's text was completely ready. The teacher's manual was also ready on July 10. Each of them was bound as a booklet of lecture notes. I sent them to some experts in Taiwan to ask for advice and feedback for revision.

There were 28 experts who received a copy of the text in June or July and 14 of the 28 who volunteered to review the teacher's manual. Attached with each copy of the student's text and the teacher's manual, there was a questionnaire to ask for comments. In all, 23 experts made comments or suggestions on the student's text and 11 of them did it before August. There were only 7 experts who provided a little advice on the teacher's manual in August. Among the 23, there were 8 mathematics educators, 6 mathematicians, 6 statisticians, 2 business statisticians, and 1 educational pschologist. Among the 7, there were 4 mathematics educators, 2 statisticians, and 1 educational pschologist.

DATA ANALYSES AND REVISIONS

The First Revision

The first revision was based on the first tryout and the experts' comments before August.

Most students in Tryout 1 were bothered by the classification of the data level of a measurement and uninterested in the distinction between continuous and discrete variables presented in chapter 1 of the text. Two experts suggested condensing the content into two chapters. Therefore, I decided to omit the difficult or uninteresting part in chapter 1 and move the introduction and some statistical anecdotes to next chapter. Then the text was arranged in two chapters.

From the tests, I found that too many students were not clear about the concepts of class limits, cumulative frequency, and cumulative relative frequency. In the questionnaires and interviews, some students also said that those terms were confusing to them. Therefore, I defined those terms more explicitly in the text and put a glossary in the summary.

The section on the stem-and-leaf display was made to the last section of the chapter. Because a stem-and-leaf plot is both a frequency distribution and a histogram, it is more meaningful to talk it after the frequency distribution and the histogram are introduced.

Responding to the comment from an expert, I changed the presentation of two examples in the text. Experts also suggested adding, rearranging, or changing exercises. Two experts recommended that the content of measures of deviation be included in the text.

For the teacher's manual, I rearranged the presentations to fit the new order of the statistical topics in the text. I added some guidelines and references for teaching the measures of deviation. By students' performance and reactions, I emphasized several instructional points in the revised

manual as follows:

1. The explanations of some ideas or concepts: (a) the meanings of the statistical table and the statistical graphs, (b) the meanings of downward and upward, (c) the distinction of a histogram and a bar graph, (d) the leaf unit and the place value of leaves, and (e) the class limits of a class.
2. The importance of the indication of the leaf unit or the place value of the leaves in a stem-and-leaf display.
3. When to use the upper limit, the lower limit, or the middle point as the abscissa of the corresponding point on a statistical graph.

The Second Revision

The second revision was based on the second tryout and the experts' comments in August. It was done before September 3.

I concluded from the students' reactions and the experts' comments that the amount of content was too great. Therefore, one of the principal tasks in revising the text was to reduce, simplify, and condense the content. Several examples were changed to exercises or made optional. The programming tasks were all optional in the revised text. In addition, a lot statistical concepts and procedures on measures of deviation were made optional.

Because the words in the text were too crowded, I enlarged the space for each word and between words. Moreover, some key points were indented to make the presentation clearer.

The cartoons in the text were improved by one of my students. He used animals as figures in the pictures. In all, there were 10 cartoons together with dialogues prepared in the new text. Each chapter contained five.

For the teacher's manual, I added more instructional key points for

teaching the last section on the measures of deviation. Some supplementary materials, references, and solutions for the last section were also added. I accepted the suggestion from one mathematics educator to put a nonte in the solutions to some exercises that may have alternative answers or provide possible answers to the question in the solution part. I also accepted the suggestion from the educational psychologist to provide solutions to all problems including the supplementary problems in the teacher's manual. I accepted two experts' suggestion to add some key points for assessment not only at the end of the General Introduction but also between the sections on Distribution of Instructional Time and Solutions of Problems for each chapter.

From the students' performance and reactions, I concluded that it was necessary to ask the students to make a distinction between the procedures for grouped and ungrouped data. I added a note in the manual to ask the teacher to pay attention to this point. In addition, teachers should be sure to emphasize the interpretation of the boxplot. The instructional time for each section in the new text was adjusted. There were seven periods for each chapter.

The Third Revision

The third revision was based on the third tryout. The students' reactions to the text and my instruction were generally favorable. However, most students thought that chapter 2 was relatively difficult for them and I taught it a little faster. Because there were some optional topics that were still provided in the text, I taught them quickly. Some studednts said that they could not understand it. Therefore, I decided to move all the optional topics to the teacher's manual as supplementary materials. Considering the students' performance, I decided to reduce some tasks in the exercises of the last chapter. However, I added one exercise to the first ex-

ercise set of chapter 1. That exercise came from the second subitem of Item 3 in the first test. Because too many students did not complete the indication of the unit price in the table when they took the test, I wanted them to get practice.

Other Comments

Experts were asked to consider whether it is appropriate to provide a descriptive statistics unit in the mathematics curriculum for the first two years in the junior college of commerce.

Nine experts' opininions were negative; 10 experts' opinions were undecided; and 10 other experts had positive opinions. The arguments of providing the unit in the curriculum were persuasive. The proper place for adding the unit should be somewhere before or after the chapter on probability. Experts also suggested to add one hour of instructional time for the mathematics course in Grade 11 to cover the added content. Some experts suggested omitting or condensing the content of some mathematical topics to make space for the new unit. Experts' suggestions could be classified into three aspects: (a) topics that were too hard, (b) topics taught in the junior middle school, and (c) topics providing no applications for business courses or business enterprises. For example, the topics on inverse trigonometric functions, solid geometry, and polar coordinates were suggested to be omitted or condensed.

FURTHER INVESTIGATIONS AND ANALYSES

Pretest

Right before Tryout 1, a pretest was given to the students in the three classes who participated in Tryout 1. The pretest consisted of three items. The data of the first two items came from the textbook Volume 3 that the students used in the first semester of Grade 8. There were 51, 48, and 53 students in the three classes who took the test. The total score for the test was 30. The arithmetic means of the students' scores in the three classes were 25.4, 25.3, and 26.1 respectively and the mean of all scores was 25.6. I concluded that the students' performance on the pretest was good. The pretest showed that Grade 11 students were prepared for learning more descriptive statistics.

Posttest and Examinations

One class in Tryout 1 (called Class A) came from the Department of Business Administration. There was another Grade 11 class (called Class D in the report) in the same department. It was not taught descriptive statistics. The average performance on the entrance examination for the junior college in these two classes was about the same. In Grade 12, the two classes were taught statistics by the same teacher. At the end of the first month, I gave them a posttest. The content of the test was covered by what had been taught in the first month of Grade 12. Their statistics teacher also gave them two examinations, that is, the midterm and the final, in the first semester of Grade 12.

There were nine questions (blanks) in the posttest to be completed. I gave one credit to each question. The average credits of Classes A and D were 7.4 and 6.7 respectively. The standard deviations were 1.54 and 2.16. Using t-test, it is found that the performance of Class A was significantly

better than that of Class D if Alpha = 0.025. The last item of the posttest asked the students to interpret a set of data on the power rates of 21 families in a village. I found that the performance of the students in Class A was better than that in Class D.

The mean scores of Classes A and D on the midterm examination were 70.12 and 70.21 and the standard deviations were 12.57 and 15.02 respectively. The mean scores of the two classes on the final examination were 70.53 and 69.52 and the standard deviations were 20.14 and 21.28 respectively. Therefore, the performance of Class A on the posttest and examinations was generally better than that of Class D. I concluded that learning descriptive statistics in the mathematics course in Grade 11 was helpful to the learning of statistics in Grade 12.

Graduates' Responses

In April, 1984, I visited the Office of Employment Guidance in the National Taipei Junior College of Commerce (TJCC) to understand the circumstances of the graduates' occupations. The office had already done an investigation by questionnaire of several aspects of the jobs of graduates from 1978 to 1983. I was more interested in what jobs the graduates were engaged in and what specialists the companies were demanding. I also tried to find out whether those jobs needed some knowledge of descriptive statistics. So I interviewed the graduates from April to September. In all, there were 43 graduates from junior colleges of commerce who were interviewed either on the phone or face to face. Thirty-eight of them graduated from the TJCC and only 5 graduated from other colleges.

Only 8 of the 43 graduates told me that some statistical ideas were involved in their work. Three of the 8 said that they needed to use statistical tables to report some statistical data. Four of the 8 said that statistical graphs, especially the bar graphs, were used in their work. Three of

the 8 said that they should compute arithmetic means in their work.

I found that there were many statistical tables and graphs in the publications from the banks or some companies. The employees in the banks and companies told me that making statistical tables and sketching statistical graphs for the journals or monthly reports were not their job. Usually, the banks and the companies asked the workers in the printing shops to do that.

I think that making statistical tables and sketching statistical graphs are too simple and too elementary to ask a graduate from the junior college of commerce to do it in the commercial enterprises. Additionally, it is not quite possible to ask a graduate from the junior college of commerce to do the work of statistical analyses at higher level. However, the procedures in descritpive statistics are basic skills. The students are supposed to know the knowledge and those procedures to understand statistical reports better. Moreover, some graduates work in the computer departments or should use computers in their work. Some computer programs are related to statistics. The graduates are supposed to learn statistics to write or use computer programs.

CONCLUSIONS, DISCUSSION, AND IMPLICATIONS

Conclusions

The students in the study had acquired some elementary knowledge and skills of descriptive statistics in the primary school and the junior middle school. The students' performance on the pretest was very good. I believe that students in other Grade 11 classes in the National Taipei Junior College of Commerce could also perform well on the pretest. I conclude that Grade 11 students in the junior college of commerce have been prepared for studying additional topics in statistics.

None of the experts I consulted thought that any of the topics in the experimental text was too difficult for Grade 11 students. Most of the students in the three tryouts also thought that the statistical content was easy for them. In addition, they thought that descriptive statistics was more interesting than most other mathematical topics. If we consider the difficulty level of the content and its interest for students, it is unreasonable to exclude a descriptive statistics unit from the mathematics curriculum for Grade 10 or 11 students.

Ten of the experts thought that a descriptive statistics unit is appropriate for the first two years in the junior college of commerce. Their arguments were persuasive. Moreover, learning descriptive statistics in Grade 11 was helpful to the learning of statistics in Grade 12. There are also advantages of a spiral curriculum design. Therefore, I advocate having a descriptive statistics unit in the mathematics program for Grade 11 students. I think that the appropriate place to insert the unit is somewhere around the chapter on probability.

Some experts thought that the amount of content in the original student's text was too great. Generally, the experts thought that the student's text was well prepared. The students' reactions to the text and my instruc-

tion were also generally favorable. Most of them liked the cartoons associated with dialogues in the text. Statistical discussions and anecdotes beyond the regular lessons were also welcomed by the students. The summary of the content seemed to help the students' learning. Detailed explanations were one feature of the experimental text. They seemed to help the students' understanding. Most students could read the text on their own and got a clear idea of the lessons. However, the text was very wordy. Some students felt that reading the content was tiresome. The topic of the stem-and-leaf display was easy to remember and most students seemed interested in it. I think that it is a good topic for the students. On the other hand, the students liked most of the methods or approaches that I used. They thought that the inquiry method and the discovery method were helpful to their learning.

Generally speaking, the students did not have serious trouble in learning the descriptive statistics unit. During Tryout 1, the students were bothered by the concept of data level and the classification of variables. During each of the three tryouts, many students had difficulty solving discovery problems provided in the exericse set or as test items although they could discover some features and characteristics of statistical tables and graphs in class under my guidance. In studying the unit, too many students were confused about the meanings of class limits, especially the upper limit of a class. I also found that many students had trouble sketching statistical graphs, especially the cumulative (relative) frequency distribution graphs and the (relative) frequency polygons. Perhaps lacking sufficient practice, too many students could not correctly compute the measures of central tendency and the measures of deviation for grouped data.

Discussion

I believe that the topic of the stem-and-leaf display can be easdily

learned by Grade 8 students. I hope that the topic can be included in the statistical unit for Grade 8 students. Considering the newest mathematics curricula for the elementary school and the junior middle school, I think that at the high school level, only a brief introduction to the uses of statistical tables and graphs is necessary. The major lessons for Grade 11 students should be on the introduction of measures of central tendency and measures of deviation. Further topics, such as z scores, probability functions, and linear correlations, can be discussed if there is enough time.

Implementing the computing activities in the mathematics course is a problem at this time because the students and the teachers did not have sufficient knowledge in programming. However, a good program in computing can motivate students' learning. I hope that the students in Grade 10 or even in the junior middle school can acquire some computing knowledge and teachniques. I also hope that there will be a program of teacher training for the teachers in the junior college of commerce. The program should include (a) mathematics courses at the graduate level; (b) statistics courses; (c) courses in commercial mathematics, commercial calculus, and commercial statistics, including a fundamental knowledge of business; (d) computer courses; and (e) courses in mathematics education, including curriculum and instruction.

Implications

The topic of descriptive statistics was regarded as easier than most other mathematical topics by the students in the TJCC. I think that students in other junior college of commerce share the same viewpoint. If a student feels that the content of descriptive statistics in the experimental text is difficult, it is likely that most mathematical topics at the high school level are also difficult for him or her. I conclude that the descriptive statistics unit is pertinent to Grade 11 students in any junior college of

commerce in Taiwan.

I have learned from this study that a good way to produce a textbook is to provide content that is not only clear but also concise. I also realize that graphs or diagrams should be properly incorporated into the prose of a mathematics textbook to keep it from appearing too wordy.

Some features, such as cartoons, statistical anecdotes or discussions, and summaries, that were provided in the students text for this study are not present in the traditional mathematics textbooks developed for students at the high school level in Taiwan. Because most students in the three [illegible] reacted well to these features, I think that mathematics curriculum [illegible] opers should consider incorporating such features into their material.

The "thinking aloud" procedure can be used to see students' thinking process. It can help us to understand the students' weakness in learning and give better instruction. I recommend it for further investigations

Final Remark

In developing the unit on descriptive statistics, I got a lot of advice from the experts for improving the curriculum materials However, some changes could not be made until the materials had been tried out in the classroom. I have concluded that experts' comments and field trials are essential for developing a curriculum. During a tryout, tests, questionnaires, and interviews are effective instruments to investigate students' learning difficulties and their reactions to the text and the instruction. I have realized that field testing is practical, helpful, and necessary in the process of developing a curriculum. I also think that if a curriculum developer can try out the materials, he or she will be more aware of the effectiveness of the curriculum materials.

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